

INTERIOR LIGHTING CALCULATIONS

To provide illumination suitable for any particular work or place necessitates a lighting system specially designed for that application. The intensity and character of the illumination most desirable for a particular installation requires careful planning and design. All of the various factors affecting the illumination must be considered, guesswork eliminated and real illuminating engineering methods practiced.

The two principal methods of calculating illumination are known as the "Point by Point" method and the "Flux of Light" or "Lumen" method.

In the "Point by Point" method it is possible to determine the illumination at any given point by mathematical computations involving the candlepower distribution of the luminaire and its position with reference to the point in question. The same procedure is necessary for every unit affecting that particular point and the sum total of the values from all units (and all lighted surfaces - reflections, etc. - if absolute accuracy is desired) is the foot-candle illumination at that point. By using this method it is possible to determine the illumination at an infinite number of points in any area and the average of these points will be representative of the average illumination for that area. This complicated but sometimes necessary procedure is covered in all the standard textbooks on Physics.

The "Flux of Light" or "Lumen" method is the accepted system usually employed in the design of general lighting installations having a number of symmetrically positioned outlets. This method assumes an average intensity of illumination needed for a given area. It only involves one simple calculation but allows for all variables affecting the illumination, such as type of lighting unit, general proportions of

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room, color of walls and ceilings, and maintenance conditions.

PROCEDURE FOR THE DESIGN OF AN
INTERIOR LIGHTING PLAN

The generally accepted procedure in making interior lighting calculations is as follows:

1. Decide the foot-candle illumination required. Refer to Table 1 for recommended values (pages 52 to 55 inclusive).
2. Select the type of lighting luminaire best adapted to the location and the activity to be performed. Refer to Table 4-A and 4-B for ratings (pages 64 and 65).
3. Determine the proper locations of outlets and mounting heights. Refer to Tables 2-A and 2-B (pages 58 and 59).
4. Determine the size of lamp to provide the necessary foot-candles with the luminaire selected, as follows:
 - (a) Select Room Index for dimensions of area by referring to Tables 3-A and 3-B (page 63).
 - (b) With Room Index as a guide find the Coefficient of Utilization from Table 4-A and 4-B (pages 64 and 65).
 - (c) Determine Depreciation Factor from Table 4-A or 4-B (pages 64 and 65).
 - (d) Calculate Area per Outlet in Square Feet.
 - (e) Calculate the lamp size (in lumens) from the simple formula on page 61 and select from Table 5, page 66, the lamp (in watts) with a lumen output nearest to the computed value.

PRESENT STANDARDS OF FOOT-CANDLE ILLUMINATION

In Table 1 are given the foot-candle values of artificial illumination that have been found by experience to be desirable for quick and comfortable vision. Where any particular operation or location is not listed, a comparable place or industry may be substituted. The foot-candle illumination values are given for an average horizontal working plane thirty inches high. Owing to the influence of local requirements and surroundings it is impossible to set any one definite value for the illumination required. Light colored working materials or merchandise, and stationary objects may permit the satisfactory use of the "Minimum Recommended" levels. On the other hand, dark colored materials, dusty

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or smoky conditions, prevalent accident hazards, aged operators, or circumstances demanding accurate visual functioning at high speeds will require even higher levels of foot-candle illumination than those recommended as good practice.

The "Good Practice" values should not be considered absolute limits or maximums, since they are frequently exceeded, particularly in places where both natural and artificial light are used simultaneously.

TABLE 1
PRESENT STANDARDS OF FOOT-CANDLE ILLUMINATION
FOR INDUSTRIAL INTERIORS

For the manufacturing processes marked with an asterisk (*) other factors, such as direction of light, are of unusual importance.

| | Foot-Candles Recommended | | | Foot-Candles Recommended | |
|---------------------------------------|--------------------------|---------|---|--------------------------|---------|
| | Good Practice | Minimum | | Good Practice | Minimum |
| Aisles, Stairways, Passageways | 3 | 2 | | | |
| Assembling: | | | Clay Products and Cements: Continued | | |
| Rough | 8 | 5 | Enameling | 10 | 6 |
| Medium | 12 | 8 | Coloring and Glazing | 15 | 10 |
| Fine | 20 | 12 | Cloth Products: | | |
| Extra Fine | 50-100 | 25 | Cutting, Inspecting, Sewing— | | |
| Automobile Manufacturing: | | | Light Goods | 15 | 10 |
| Automatic Screw Machines | 15 | 10 | Dark Goods | 50-100 | 25 |
| Assembly Line | 15 | 10 | Pressing, Cloth Treating (oil | | |
| Frame Assembly | 12 | 8 | cloth, etc.)— | | |
| Tool Making | 20 | 12 | Light Goods | 12 | 8 |
| Body Manufacturing— | | | Dark Goods | 20 | 12 |
| Assembly | 15 | 10 | Coal Breaking, and Washing, | | |
| *Finishing and Inspecting | 50-100 | 25 | Screening | 5 | 3 |
| Bakeries | 12 | 8 | Construction, Indoor, General | 5 | 3 |
| Book Binding: | | | Dairy Products: | 12 | 8 |
| Folding, Assembling, Pasting, | | | Electric Manufacturing: | | |
| Etc. | 8 | 5 | Storage Battery, Molding of | | |
| Cutting, Punching and Stitch- | | | Grids, Charging Room | 10 | 6 |
| ing | 12 | 8 | Coil and Armature Winding, | | |
| Embossing | 15 | 10 | Mica Working, Insulating Pro- | | |
| Candy Making | 12 | 8 | cesses | 20 | 12 |
| Canning and Preserving | 12 | 8 | Elevator: | | |
| Chemical Works: | | | Freight and Passenger | 8 | 5 |
| Hand Furnaces, Boiling Tanks, | | | Engraving | 50-100 | 25 |
| Stationary Driers, Stationary | | | Forge Shops and Welding | 10 | 6 |
| or Gravity Crystallizing | 5 | 3 | Foundries: | | |
| Mechanical Furnaces, Genera- | | | Charging floor, Tumbling, | | |
| tors and Stills, Mechanical | | | Cleaning, Pouring and Shaking | | |
| Driers, Evaporators, Filtra- | | | Out | 8 | 5 |
| tion, Mechanical Crystal- | | | Rough Molding and Core Mak- | | |
| lizing, Bleaching | 6 | 4 | ing | 10 | 6 |
| Tanks for Cooking, Extractors, | | | Fine Molding and Core Making | 15 | 10 |
| Percolators, Nitrators, Elec- | | | Garage—Automobiles: | | |
| trolytic Cells | 10 | 6 | Storage—Dead | 3 | 2 |
| Clay Products and Cements: | | | Live | 8 | 5 |
| Grinding, Filter Presses, Kiln | | | Repair Department and Wash- | | |
| Rooms | 5 | 3 | ing | 15 | 10 |
| Molding, Pressing, Cleaning | | | | | |
| and Trimming | 8 | 5 | | | |



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TABLE 1—Continued

| | Foot-Candles Recommended | | | Foot-Candles Recommended | |
|--|--------------------------|---------|--|--------------------------|---------|
| | Good Practice | Minimum | | Good Practice | Minimum |
| Shoe Manufacturing: | | | | | |
| Hand Turning, Miscellaneous Bench and Machine Work.... | 12 | 8 | | | |
| Inspecting and Sorting Raw Material, Cutting, Lasting and Welting (light)..... | 15 | 10 | | | |
| Inspecting and Sorting Raw Material, Cutting, Stitching (dark)..... | 50-100 | 25 | | | |
| Soap Manufacturing: | | | | | |
| Kettle Houses, Cutting, Soap Chip and Powder..... | 8 | 5 | | | |
| Stamping, Wrapping, Packing, Filling and Packing Soap Powder..... | 10 | 6 | | | |
| Steel and Iron Mills, Bar, Sheet and wire Products: | | | | | |
| Soaking Pits and Reheating Furnaces..... | 3 | 2 | | | |
| Charging and Casting Floors..... | 6 | 4 | | | |
| Muck and Heavy Rolling, Shearing (rough by gauge,) Pickling and Cleaning..... | 8 | 5 | | | |
| Plate Inspection, Chipping... Automatic Machines, Rod, Light and Cold Rolling, Wire Drawing, Shearing (fine by line) | 25 | 15 | | | |
| | 12 | 8 | | | |
| Steel Fabrication, Girder and Truss Assembly..... | 10 | 6 | | | |
| Stone Crushing and Screening | | | | | |
| Belt conveyor tubes, Main Line Shafting, Spaces, Chute Rooms, Inside of Bins..... | 3 | 2 | | | |
| Primary Breaker Room, Auxiliary Breakers under Bins..... | 5 | 3 | | | |
| Screen Rooms..... | 8 | 5 | | | |
| Store and Stock Rooms: | | | | | |
| Rough bulky Material..... | 3 | 2 | | | |
| Medium or Fine Material Requiring Care..... | 8 | 5 | | | |
| Sugar Grading..... | 25 | 15 | | | |
| Testing: | | | | | |
| Rough..... | 8 | 5 | | | |
| Fine..... | 15 | 10 | | | |
| | | | Extra Fine Instruments, Scales, etc..... | 50-100 | 25 |
| | | | Textile Mills: | | |
| | | | Cotton— | | |
| | | | Opening and Lapping, Carding, Drawing-Frame, Roving, Dyeing..... | 8 | 5 |
| | | | Spooling, Spinning, Drawing-in, Warping, Weaving, Quilling, Inspecting, Knitting, Slashing, (over beam end)..... | 12 | 8 |
| | | | Silk— | | |
| | | | Winding, Throwing, Dyeing, Quilling, Warping, Weaving, and Finishing— | 12 | 8 |
| | | | Light Goods..... | 15 | 10 |
| | | | Dark Goods..... | 20 | 15 |
| | | | Woolen— | | |
| | | | Carding, Picking, Washing and Combing..... | 6 | 4 |
| | | | Twisting and Dyeing..... | 10 | 6 |
| | | | Drawing-in, Warping— | | |
| | | | Light Goods..... | 10 | 6 |
| | | | Dark Goods..... | 15 | 10 |
| | | | Weaving— | | |
| | | | Light Goods..... | 12 | 8 |
| | | | Dark Goods..... | 20 | 12 |
| | | | Knitting Machines..... | 15 | 10 |
| | | | Tobacco Products: | | |
| | | | Drying, Stripping, General... Grading and Sorting..... | 3 | 2 |
| | | | | 25 | 15 |
| | | | Toilet and Washrooms..... | 6 | 4 |
| | | | Upholstering: | | |
| | | | Automobile, Coach and Furniture..... | 15 | 10 |
| | | | Warehouse..... | 3 | 2 |
| | | | Woodworking: | | |
| | | | Rough Sawing and Bench Work Sizing, Planing, Rough Sanding, Medium Machine and Bench Work, Gluing, Veneering, Cooperage..... | 8 | 5 |
| | | | | 12 | 8 |
| | | | Fine Bench and Machine Working, Fine Sanding and Finish.. | 15 | 10 |

PRESENT STANDARDS OF FOOT-CANDLE ILLUMINATION FOR COMMERCIAL AND PUBLIC INTERIORS

| | Foot-Candles Recommended | | | Foot-Candles Recommended | |
|--|--------------------------|---------|---|--------------------------|---------|
| | Good Practice | Minimum | | Good Practice | Minimum |
| Armories: | | | | | |
| Drill Sheds..... | 10 | 6 | | | |
| Exhibition Halls..... | 12 | 8 | | | |
| Art Galleries: | | | | | |
| General..... | 5 | 3 | | | |
| On Paintings..... | 25-100 | 10 | | | |
| Auditoriums..... | 5 | 3 | | | |
| Automobile Show Rooms..... | 15 | 10 | | | |
| Bank: | | | | | |
| Lobby..... | 10 | 6 | | | |
| Cages and Offices..... | 15 | 10 | | | |
| Barber Shop..... | 15 | 10 | | | |
| Base Ball—Indoor Game..... | 15 | 10 | | | |
| Basket Ball..... | 15 | 10 | | | |
| Bowling—on Alley, Runway and Seats..... | 8 | 5 | | | |
| On Pins..... | 25 | 15 | | | |
| | | | Billiards: | | |
| | | | General..... | 6 | 4 |
| | | | On Table..... | 25 | 15 |
| | | | Cars: | | |
| | | | Baggage, Day Coach, Dining and Pullman..... | 8 | 5 |
| | | | Mail— | | |
| | | | Bag Racks..... | 12 | 8 |
| | | | Letter Cases..... | 15 | 10 |
| | | | Storage..... | 6 | 4 |
| | | | Street, Railway and Subway..... | 10 | 6 |
| | | | Churches: | | |
| | | | Auditorium..... | 3 | 2 |
| | | | Sunday School Room..... | 8 | 5 |
| | | | Pulpit or Restrum..... | 12 | 8 |
| | | | Art Glass Windows..... | 25-50 | 15 |
| | | | Club Rooms: | | |
| | | | Lounge..... | 5 | 3 |
| | | | Reading Room..... | 12 | 8 |



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TABLE 1—Continued

| | Foot-Candles Recommended | | | Foot-Candles Recommended | |
|--|--------------------------|---------|---|--|---------|
| | Good Practice | Minimum | | Good Practice | Minimum |
| Court Rooms | 10 | 6 | Racquet | 25 | 15 |
| Dance Halls | 6 | 4 | Schools: | | |
| Dental Offices: | | | Auditorium..... | 8 | 5 |
| Waiting Room..... | 6 | 4 | Class Rooms, Library and Office..... | 12 | 8 |
| Operating Office..... | 12 | 8 | Corridors and Stairways..... | 5 | 3 |
| Dental Chair..... | 50 | 25 | Drawing..... | 25 | 15 |
| Depot Waiting Room | 8 | 5 | Laboratories..... | 12 | 8 |
| Drafting Room | 25 | 15 | Manual Training..... | 12 | 8 |
| Elevator—Freight and Passenger | 6 | 4 | Sewing Rooms..... | 25 | 15 |
| Fire Engine House: | | | Study Room— | | |
| When alarm is turned in..... | 8 | 5 | Desks..... | 12 | 8 |
| At other times..... | 3 | 2 | Blackboards..... | 12 | 8 |
| Garage—Automobiles: | | | Show Cases | Two to four times that of the store proper | |
| Storage—Dead..... | 3 | 2 | Show Windows: | | |
| Storage—Live..... | 8 | 5 | Large Cities— | | |
| Repair Dept. and Washing.... | 15 | 10 | Brightly Lighted Districts.. | 150 | 100 |
| Gymnasiums: | | | Secondary Business Locations..... | 75 | 50 |
| Main Exercising Floor..... | 12 | 8 | Neighborhood Stores..... | 50 | 30 |
| Swimming Pool..... | 8 | 5 | Medium Cities— | | |
| Shower Rooms..... | 6 | 4 | Brightly Lighted Districts.. | 75 | 50 |
| Locker Rooms..... | 6 | 4 | Neighborhood Stores..... | 50 | 30 |
| Fencing, Boxing, Wrestling.... | 12 | 8 | Small Cities and Towns..... | 50 | 30 |
| Halls, Passageways in Interiors | 3 | 2 | Lighting to Reduce Daylight Window Reflections..... | 200-1000 | |
| Handball | 25 | 15 | Skating Rink (Indoor) | 8 | 5 |
| Hospitals: | | | Squash | 25 | 15 |
| Lobby and Reception Room.. | 6 | 4 | Stores: | | |
| Corridors..... | 3 | 2 | Large Specialty and Department Stores— | | |
| Wards (with local illumination) | 5 | 3 | Main Floors..... | 15 | 10 |
| Private Rooms..... | 8 | 5 | Other Floors..... | 12 | 8 |
| Night Illumination..... | 0.2 | 0.1 | Basement Store..... | 15 | 10 |
| Operating Table..... | 100-200 | 75 | Small Stores— | | |
| Operating Room..... | 15 | 10 | Art..... | 12 | 8 |
| Laboratories..... | 15 | 10 | Automobile Supply..... | 12 | 8 |
| Hotels: | | | Bake Shop..... | 12 | 8 |
| Lobby..... | 8 | 5 | Book..... | 12 | 8 |
| Dining Room..... | 6 | 4 | China..... | 12 | 8 |
| Kitchen..... | 10 | 6 | Cigar..... | 15 | 10 |
| Bed Rooms..... | 8 | 5 | Clothing..... | 15 | 10 |
| Corridors..... | 3 | 2 | Confectionery..... | 12 | 8 |
| Writing Room..... | 12 | 8 | Dairy Products..... | 12 | 8 |
| Library: | | | Decorator..... | 12 | 8 |
| Reading Rooms..... | 12 | 8 | Drug..... | 15 | 10 |
| Stack Room..... | 6 | 4 | Dry Goods..... | 15 | 10 |
| Lodge Rooms | 6 | 4 | Electrical Supply..... | 15 | 10 |
| Lunch Room | 12 | 8 | Florist..... | 12 | 8 |
| Market | 12 | 8 | Furrier..... | 15 | 10 |
| Moving Picture Theatre: | | | Grocery..... | 12 | 8 |
| During Intermission..... | 5 | 3 | Haberdashery..... | 15 | 10 |
| During Pictures..... | | 0.1 | Hardware..... | 12 | 8 |
| Museum: | | | Hat..... | 15 | 10 |
| General..... | 8 | 5 | Jewelry..... | 15 | 10 |
| Special Exhibits..... | 25-100 | 10 | Leather, Handbags and Trunks..... | 12 | 8 |
| Office Buildings: | | | Meat..... | 12 | 8 |
| Private and General Offices— | | | Millinery..... | 15 | 10 |
| Close Work..... | 15 | 10 | Music..... | 12 | 8 |
| No Close Work..... | 10 | 8 | Notions..... | 12 | 8 |
| File Room..... | 6 | 4 | Piano..... | 12 | 8 |
| Vault..... | 6 | 4 | Shoe..... | 15 | 10 |
| Reception Room..... | 6 | 4 | Sporting Goods..... | 12 | 8 |
| Post Office: | | | Tailor..... | 15 | 10 |
| Lobby..... | 10 | 6 | Tobacco..... | 15 | 10 |
| Work Room— | | | Variety Store..... | 15 | 10 |
| Sorting, Mailing, etc..... | 15 | 10 | Telephone Exchange: | | |
| Storage..... | 10 | 6 | Operating Rooms..... | 8 | 5 |
| Private and General Offices... | 15 | 10 | Terminal Rooms..... | 12 | 8 |
| File Room and Vault..... | 6 | 4 | Cable Vaults..... | 6 | 4 |
| Corridors and Stairways..... | 3 | 2 | Tennis (Indoor) | 25-50 | 15 |
| Railway: | | | Theatres: | | |
| Depot—Waiting Room..... | 8 | 5 | Auditorium..... | 3 | 2 |
| Ticket Offices..... | 12 | 8 | Foyer..... | 8 | 5 |
| Rest Room—Smoking Room.... | 8 | 5 | Lobby..... | 12 | 8 |
| Baggage Room— | | | Toilet and Washrooms | 6 | 4 |
| Checking Office..... | 12 | 8 | | | |
| Storage..... | 6 | 4 | | | |
| Concourse..... | 6 | 4 | | | |
| Train Platform..... | 4 | 2 | | | |
| Restaurants | 8 | 5 | | | |

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SELECTION OF EQUIPMENT

The character of the work to be performed, the construction of the room or building, and the color of walls and ceilings determine to a large extent the type of lighting equipment to be selected.

In industrial locations where appearance is an unimportant factor and maximum efficiency is desired, open bottom reflectors such as the RLM standard dome and prismatic glass industrial reflectors should be used. Where such equipment is suspended less than 20 feet from the floor the use of white bowl lamps is recommended. For greater diffusion, softer shadows and a lower brightness of the light source, the Glassteel Diffuser is recommended.

For commercial applications such as stores, offices and schoolrooms, both the appearance and the efficiency of the luminaires must be considered. Enclosing glass globes are the types usually and most satisfactorily employed for such purposes. Where better quality of illumination is desired the semi-indirect and totally indirect luminaires can be used at slightly lower efficiencies. In all lighting installations the color of interior surfaces has a material effect upon the resultant illumination. This is particularly true of indirect lighting, where ceilings and upper side walls must be painted and maintained in light colors. Obviously the lighting equipment itself must also be properly and regularly relamped and cleaned.

Other conditions influencing the choice of lighting equipment are: appearance of the lighted room, direct and reflected glare, shadows, vertical illumination and ease of cleaning and relamping. These points are covered in Table 4-A and 4-B under the caption: "A Guide to the Selection of Lighting Equipment."

Authorities agree that lighting glassware suspended in the line of vision should not have a surface brightness in excess of 3.5 candles per square inch.

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As a further aid in the selection of proper lighting equipment the following table is given.

RECOMMENDED GLOBE SIZES OF HIGH EFFICIENCY, GOOD DIFFUSING GLASS WHEN USED UNSHIELDED*

| LAMP SIZE (WATTS) | GLOBE DIAMETER (INCHES) | BRIGHTNESS OF BRIGHTEST SQUARE INCH ** (APPROX. CANDLES) (PER SQ. IN.) |
|----------------------|----------------------------|---|
| 50 - 60 | 8 | 2.5 |
| 60 - 100 | 10 | 2.5 |
| 100 - 150 | 12 | 3.0 |
| 150 - 200 | 14 | 3.5 |
| 200 - 300 | 16 | 4.0 |
| 300 - 500 | 18 | 5.0 |

*The globes are assumed to be substantially uniform in brightness

**Values are obtained with the larger size of lamps

POSITION OF OUTLETS AND MOUNTING HEIGHTS

In a well planned lighting installation the outlets for luminaires should be so located that there will be no light or dark areas, i.e., "spotty illumination". It is obviously desirable for economic reasons to suspend the lighting equipment as high as practicable to permit maximum spacing of outlets and reduce the number required and thus lessen the cost of installation and operation. The units should not be spaced more than one and one-half times their mounting height if uniform illumination is to be obtained. Frequently the character of work and the desirability of having a minimum of shadow, or the arrangement of machines, will justify spacings considerably less than the maximum permissible.

The height of the light source above the floor is obviously governed by the height of the ceiling and is usually the determining factor in the spacing of outlets. Sometimes, however, the placing of

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outlets is fixed by the location of columns or ceiling beams which divide the room into definite sections or bays. For the majority of bays, a symmetrical arrangement of outlets is possible and should be taken advantage of.

When outlets are finally located they should be adequately wired to meet present and possible future needs; thus, at some later date, if it is desirable to increase the wattage of the lamps, no change in wire size will be necessary. (See also pages 66 and 67).

The mounting height for direct lighting equipment is always measured from the floor to the luminaire and for indirect lighting equipment from the ceiling to the luminaire.

Tables 2-A and 2-B have been arranged as convenient guides to determine the proper spacings and mounting heights for all classes of equipment commonly used in commercial and industrial lighting. Where the ceiling determines the height at which the lighting equipment should be mounted the usual and maximum spacings can be obtained from the following table:

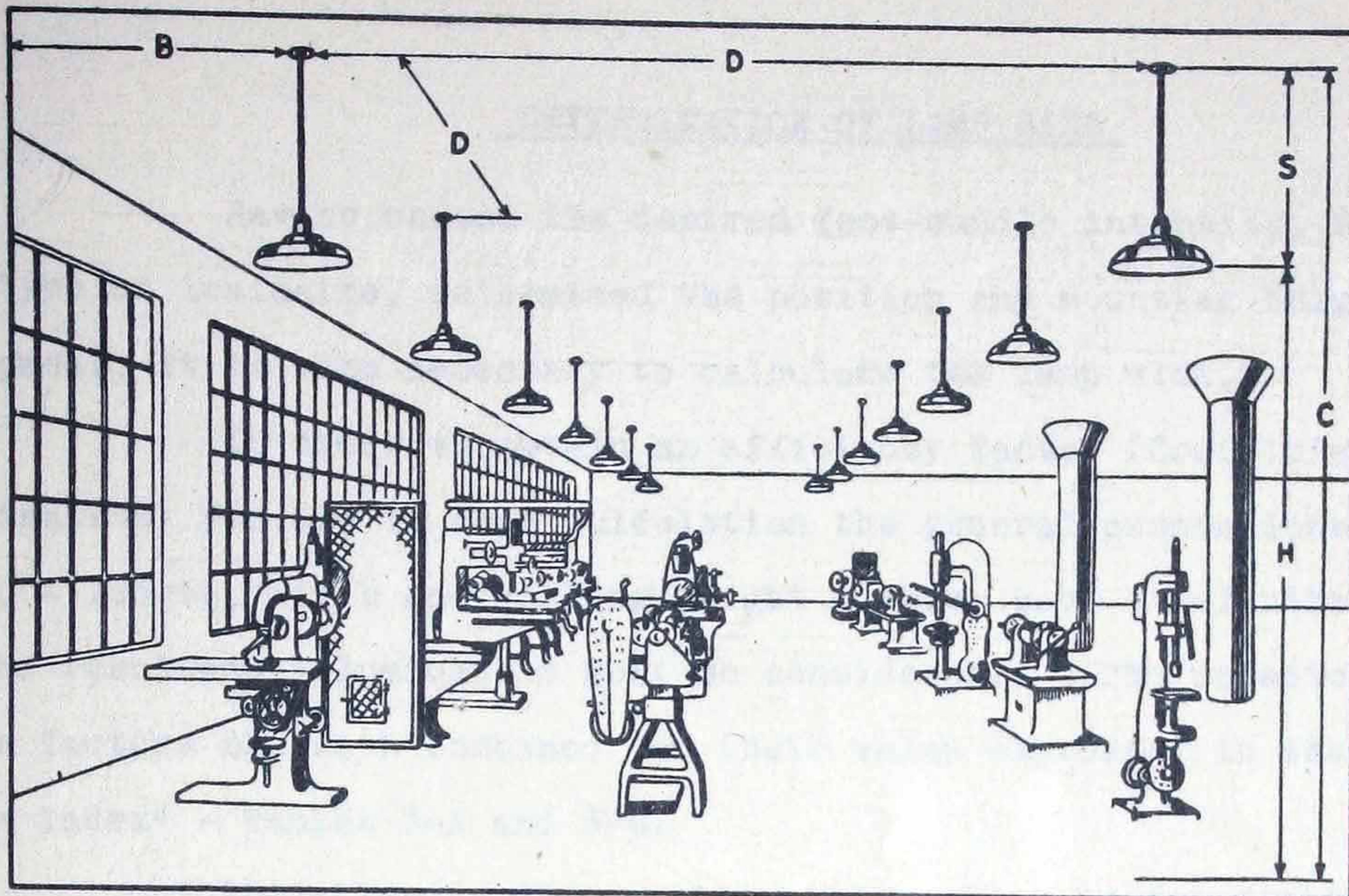
TABLE 2-A—SPACING OF OUTLETS

| Ceiling Height (Or Height in the Clear) (C) | Spacing Between Outlets | | Spacing Between Outside Outlets and Wall | | Approximate Area per Outlet (At Usual Spacings) |
|---|-------------------------|--|---|---|--|
| | Usual (D) | Maximum (For Units at Ceiling) (D) | Aisles or Storage Next to Wall | Desks, Workbenches, etc., Against Wall (B) | |
| (Feet) | (Feet) | Not more than* | | Not more than* | (Square Feet) |
| 8 | 7 | 7½ | Usually one-half actual spacing between units | 3 | 50-60 |
| 9 | 8 | 8 | | 3 | 60-70 |
| 10 | 9 | 9 | | 3½ | 70-85 |
| 11 | 10 | 10½ | | 3½ | 85-100 |
| 12 | 10-12 | 12 | | 3½-4 | 100-150 |
| 13 | 10-12 | 13 | | 3½-4½ | 100-150 |
| 14 | 10-13 | 15 | | 4-5 | 100-170 |
| 15 | 10-13 | 17 | | 4-5 | 100-170 |
| 16 | 10-13 | 19 | | 4-6 | 100-170 |
| 18 | 10-20 | 21 | | 4-6 | 100-400 |
| 20 | 18-24 | 24 | | 5-7 | 300-500 |
| 22 | 20-25 | 27 | | 5-7 | 400-600 |
| 24 | 20-30 | 30 | | 6-8 | 400-900 |
| 26 | 25-30 | 33 | | 8-9 | 600-900 |
| 30 and up | 25-30 | 40 | | 8-10 | 600-900 |

* Where it is definitely known that some form of indirect lighting will be used, the maximum spacing between outlets may be increased about two feet, and the distance from the outside outlets to the wall may be increased by one foot.

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Where building columns, trusses or exposed beams determine the most logical and symmetrical arrangement of outlets, the minimum spacings as well as the desirable mounting heights can be obtained from the following table:

TABLE 2-B—MOUNTING HEIGHT OF LIGHTING UNITS

| DIRECT LIGHTING UNITS | | | | SEMI-INDIRECT AND INDIRECT LIGHTING | |
|--|---|---|--|-------------------------------------|---|
| Actual Spacing Between Units (D) | Distance of Units from Floor Not Less Than (H) | Desirable Mounting Height in Industrial Interiors | Desirable Mounting Height in Commercial Interiors | Actual Spacing Between Units (D) | Recommended Suspension Length (Top of Bowl to Ceiling) (S) |
| (Feet) | (Feet) | 12 feet above floor if possible—to avoid glare, and still be within reach from stepladder for cleaning. | The actual hanging height should be governed largely by general appearance, but particularly in offices and drafting rooms, the minimum values shown in Column H should not be violated. | (Feet) | (Feet) |
| 7 | 8 | | | 7 | 1-3 |
| 8 | 8½ | | | 8 | 1-3 |
| 9 | 9 | | | 9 | 1-3 |
| 10 | 10 | 10 | | 1½-3 | |
| 11 | 10½ | 11 | | 2-3 | |
| 12 | 11 | 12 | | 2-3 | |
| 14 | 12½ | 14 | | 2½-4 | |
| 16 | 14 | 16 | | 3-4 | |
| 18 | 15 | 18 | | 3-4 | |
| 20 | 16 | 20 | | 4-5 | |
| 22 | 18 | 22 | | 4-5 | |
| 24 | 20 | 24 | | 4-6 | |
| 26 | 21 | 26 | | 4-6 | |
| 28 | 22 | 28 | | 5-7 | |
| 30 | 24 | 30 | 5-7 | | |
| Where units are to be mounted much more than 12 feet it is usually desirable to mount the units at ceiling or on roof trusses. | | | | | |

Tables 2-A and 2-B are based upon the assumption that the plane of work is 30 inches above the floor.



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DETERMINATION OF LAMP SIZE

Having chosen the desired foot-candle intensity, selected the type of luminaire, determined the position and mounting height of the equipment, it is then necessary to calculate the lamp size.

In order to obtain an efficiency factor (Coefficient of Utilization) for use in this calculation the general proportions of the room, - length, width and ceiling height - which have a definite bearing on the resultant illumination must be considered. The relationship of these factors has been combined and their value expressed in the term "Room Index" - Tables 3-A and 3-B.

The illumination on the working plane is dependent in large measure upon the color of the surroundings. Light walls and ceilings reflect light rays falling upon them and absorb only a small portion. Thus they contribute to efficient lighting. Since luminaires and wall surfaces absorb a certain percentage of light, the useful illumination on a working plane is always less than that generated by the source. The ratio between the light reaching a working plane and the light generated by a lamp in any particular luminaire operating under given surroundings, is known as the Coefficient of Utilization, Tables 4-A and 4-B.

Due to their construction and shape some luminaires collect dust and dirt more rapidly than others and thus have different operating efficiencies. The probable service efficiency with clean, average or dirty surroundings is given as a decimal in Tables 4-A and 4-B and is known as the Depreciation Factor.

The area illuminated by each lamp is equal to the total area to be lighted divided by the number of outlets.

$$\text{Area per Outlet} = \frac{\text{Total Area}}{\text{Number of Outlets}}$$

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These several factors are combined in the following formula to determine lamp size:

$$\text{Lumens of Lamp} = \frac{\text{Area per Outlet} \times \text{Foot-Candles}}{\text{Depreciation Factor} \times \text{Coef. of Utilization}}$$

The lamp size, in watts, may now be selected from Table 5, page 66, choosing the lamp having an output nearest the lumen value of figures obtained for "Lumens of Lamp" from the above formula. Frequently, the solution of the formula will give a lumen value falling in between the rated outputs of standard lamps. In such cases the illumination that would be obtained from the next higher or next lower wattage lamp can be determined from the following computation:

$$\frac{\text{Lumen Output (Table 5)}}{\text{"Lumens of Lamp" (above formula)}} \times \text{Foot-Candles Selected} = \text{Actual Illumination}$$

A lamp having exactly the light output of the calculated lumens will furnish an average illumination equal to the foot-candle intensity selected at the beginning of the calculations.

Every surface reflects a certain percentage of the light which strikes it, depending upon its texture and color. The accompanying table, page 62, gives the percentage of light reflected from typical walls and ceilings usually found in commercial and industrial interiors, and will be a guide in selecting the Coefficient of Utilization in Tables 4-A and 4-B.

The character and condition of walls and ceilings have a direct bearing upon the illumination obtained from any installation of luminaires. Since the ceilings and upper walls are really secondary sources reflecting the light that reaches them, it is of the utmost importance that these surfaces be maintained in as light shades as practicable. Light is reflected and re-reflected a number of times, hence a slight increase in the percentage of reflection will be accompanied by a considerable increase in the resulting illumination. In general, all

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TABLE 3-B

ROOM INDEX FOR LARGE HIGH ROOMS

| For Indirect Lighting Use Ceiling Height | | FEET | | | | | | | | | |
|---|-----------------------|--------------|--------------|--------------|-------------|-------------|-------------|-------------|-------------|-------------|-----|
| | | 14 to 16½ | 17 to 20 | 21 to 24 | 25 to 30 | 31 to 36 | 37 to 50 | | | | |
| For Direct Lighting Use Mounting Height | | 10 to 11½ | 12 to 13½ | 14 to 16½ | 17 to 20 | 21 to 24 | 25 to 30 | 31 to 36 | 37 to 50 | 37 to 50 | |
| | | FEET | | | | | | | | | |
| Room Width (Feet) | Room Length (Feet) | ROOM INDEX | | | | | | | | | |
| 14 (13-15½) | 14-20 | 1.0 | 0.8 | 0.6 | 0.6 | | | | | | |
| | 20-30 | 1.0 | 0.8 | 0.6 | 0.6 | | | | | | |
| | 30-42 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 | | | | | |
| | 42-60 | 1.5 | 1.0 | 0.8 | 0.6 | 0.6 | 0.6 | | | | |
| | 60-90 | 1.5 | 1.2 | 1.0 | 0.6 | 0.6 | 0.6 | 0.6 | | | |
| 17 (16-18½) | 14-20 | 1.0 | 0.8 | 0.6 | 0.6 | | | | | | |
| | 20-30 | 1.2 | 1.0 | 0.8 | 0.6 | | | | | | |
| | 30-42 | 1.2 | 1.0 | 1.0 | 0.6 | 0.6 | | | | | |
| | 42-60 | 1.5 | 1.2 | 1.2 | 0.8 | 0.6 | 0.6 | 0.6 | | | |
| | 60-110 | 1.5 | 1.2 | 1.2 | 0.8 | 0.6 | 0.6 | 0.6 | 0.6 | | |
| 20 (19-21½) | 14-20 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | | | | |
| | 20-30 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 | | | | | |
| | 30-42 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 | | | | |
| | 42-60 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 | 0.6 | | |
| | 60-90 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| 24 (22-26) | 14-20 | 2.0 | 1.5 | 1.5 | 1.0 | 1.0 | 0.8 | 0.6 | | | |
| | 20-30 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 | | | | |
| | 30-42 | 1.5 | 1.2 | 1.2 | 0.8 | 0.6 | 0.6 | 0.6 | | | |
| | 42-60 | 2.0 | 1.5 | 1.5 | 1.0 | 0.8 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| | 60-140 | 2.0 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.8 | 0.6 | 0.6 | 0.6 |
| 30 (27-33) | 14-20 | 2.0 | 1.5 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | | | |
| | 20-30 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 | | | |
| | 30-42 | 2.5 | 1.5 | 1.5 | 1.0 | 0.8 | 0.6 | 0.6 | 0.6 | | |
| | 42-60 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 | 0.6 | 0.6 |
| | 60-140 | 2.5 | 2.0 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.8 | 0.6 | 0.6 |
| 36 (34-39) | 14-20 | 2.5 | 2.0 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | | | |
| | 20-30 | 2.0 | 1.5 | 1.5 | 1.0 | 0.8 | 0.6 | 0.6 | | | |
| | 30-42 | 2.0 | 1.5 | 1.5 | 1.0 | 0.8 | 0.6 | 0.6 | 0.6 | | |
| | 42-60 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 | 0.6 | 0.6 |
| | 60-140 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.8 | 0.6 | 0.6 |
| 42 (40-45) | 14-20 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | | | |
| | 20-30 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | | |
| | 30-42 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 | 0.6 |
| | 42-60 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 | 0.6 |
| | 60-140 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 | 0.6 |
| 50 (46-55) | 14-20 | 3.0 | 2.5 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | | | |
| | 20-30 | 3.0 | 2.5 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 | | |
| | 30-42 | 3.0 | 2.5 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 | 0.6 | 0.6 |
| | 42-60 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 | 0.6 |
| | 60-140 | 3.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.8 | 0.8 |
| 60 (56-67) | 14-20 | 3.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | | | |
| | 20-30 | 3.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 | | |
| | 30-42 | 3.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 | 0.6 | 0.6 |
| | 42-60 | 3.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 | 0.6 | 0.6 |
| | 60-140 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 | 0.6 | 0.6 |
| 75 (68-90) | 14-20 | 4.0 | 3.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | | | |
| | 20-30 | 4.0 | 3.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 0.6 | | |
| | 30-42 | 4.0 | 3.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 0.6 | 0.6 | 0.6 |
| | 42-60 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 0.6 | 0.6 | 0.6 |
| | 60-140 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 0.6 | 0.6 | 0.6 |
| 90 or more | 14-20 | 5.0 | 4.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | | | |
| | 20-30 | 5.0 | 4.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 0.6 | | |
| | 30-42 | 5.0 | 4.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 0.6 | 0.6 | 0.6 |
| | 42-60 | 5.0 | 4.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 0.6 | 0.6 | 0.6 |
| | 60-140 | 5.0 | 4.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 0.6 | 0.6 | 0.6 |

TABLE 3-A

ROOM INDEX FOR NARROW AND AVERAGE ROOMS

| For Indirect Lighting } Use Ceiling Height } | | FEET | | | | | | | | | |
|---|-----------------------|-------------|--------------|--------------|--------------|--------------|--------------|-------------|-----|-----|-----|
| | | 9 and 9½ | 10 to 11½ | 12 to 13½ | 14 to 16½ | 17 to 20 | 21 to 24 | 25 to 30 | | | |
| For Direct Lighting } Use Mounting Height } | | FEET | | | | | | | | | |
| | | 7 and 7½ | 8 and 8½ | 9 and 9½ | 10 to 11½ | 12 to 13½ | 14 to 16½ | 17 to 20 | | | |
| Room Width (Feet) | Room Length (Feet) | ROOM INDEX | | | | | | | | | |
| 9 (8½-9½) | 8-10 | 1.0 | 0.8 | 0.6 | 0.6 | | | | | | |
| | 10-14 | 1.0 | 0.8 | 0.8 | 0.6 | | | | | | |
| | 14-20 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 | | | | | |
| | 20-30 | 1.2 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 | | | | |
| | 30-42 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 | 0.6 | | | |
| 10 (9½-10½) | 42-up | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| | 10-14 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 | | | | | |
| | 14-20 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 | 0.6 | | | | |
| | 20-30 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 | 0.6 | | | |
| | 30-42 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| 12 (11-12½) | 42-60 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| | 60-up | 2.0 | 1.5 | 1.5 | 1.0 | 1.0 | 0.8 | | | | |
| | 10-14 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 | 0.6 | | | | |
| | 14-20 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 | 0.6 | | | |
| | 20-30 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| 14 (13-15½) | 30-42 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| | 42-60 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| | 60-90 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 | 0.6 | 0.6 |
| | 90-up | 2.5 | 2.0 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 | 0.6 |
| | 14-20 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| 17 (16-18½) | 20-30 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| | 30-42 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 | 0.6 | 0.6 |
| | 42-60 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 | 0.6 | 0.6 |
| | 60-90 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 | 0.6 | 0.6 |
| | 90-110 | 2.5 | 2.0 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 | 0.6 |
| 20 (19-21½) | 110-up | 3.0 | 2.5 | 2.0 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 |
| | 20-30 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 | 0.6 | 0.6 |
| | 30-42 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 | 0.6 | 0.6 |
| | 42-60 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 | 0.6 | 0.6 |
| | 60-90 | 3.0 | 2.5 | 2.0 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 |
| 24 (22-26) | 90-140 | 3.0 | 2.5 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 |
| | 140-up | 3.0 | 2.5 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 |
| | 20-30 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 | 0.6 | 0.6 |
| | 30-42 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 | 0.6 |
| | 42-60 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 | 0.6 |
| 30 (27-33) | 60-90 | 3.0 | 2.5 | 2.0 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 |
| | 90-140 | 3.0 | 2.5 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 |
| | 140-180 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 |
| | 180-up | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 |
| | 30-42 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 | 0.6 |
| 36 (34-39) | 42-60 | 3.0 | 2.5 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 |
| | 60-90 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 |
| | 90-140 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 |
| | 140-200 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 |
| | 200-up | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 |
| 40 or more | 30-42 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 |
| | 42-60 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 | 0.6 |
| | 60-90 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 |
| | 90-140 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 |
| | 140-200 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.8 | 0.6 |
| | | 200-up | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 42-60 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 60-90 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 90-140 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 140-200 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 200-up | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 42-60 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 60-90 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 90-140 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 140-200 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 200-up | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 42-60 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 60-90 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 90-140 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 140-200 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 200-up | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 42-60 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 60-90 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 90-140 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 140-200 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 200-up | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 42-60 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 60-90 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 90-140 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 140-200 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 200-up | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 42-60 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 60-90 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 90-140 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 140-200 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 200-up | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 42-60 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 60-90 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 90-140 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 140-200 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 200-up | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 42-60 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 60-90 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 90-140 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 140-200 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 200-up | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 42-60 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 60-90 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 90-140 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 140-200 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 200-up | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 42-60 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 60-90 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 90-140 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 140-200 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 200-up | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 42-60 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 60-90 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 90-140 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 140-200 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 200-up | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 42-60 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 60-90 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 90-140 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 140-200 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 200-up | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 42-60 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 60-90 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 90-140 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 140-200 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 200-up | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 42-60 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 60-90 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 90-140 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 140-200 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 200-up | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 42-60 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 60-90 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 90-140 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 140-200 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 200-up | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 42-60 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 60-90 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 90-140 | 5.0 | 4.0 | 3.0 | 2.5 | 2.0 | 1.5 | 1.2 | 1.0 | 0.6 |
| | | 140-200 | | | | | | | | | |

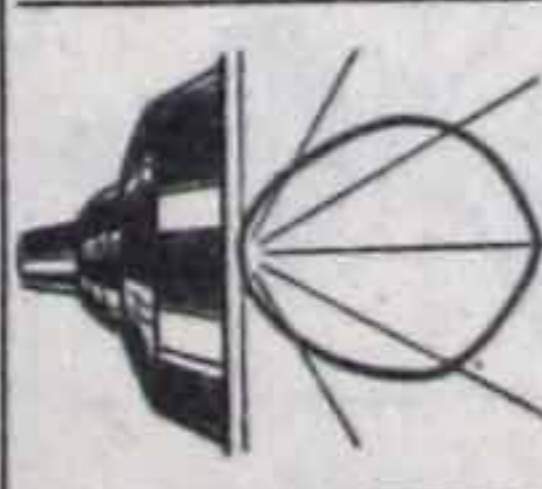
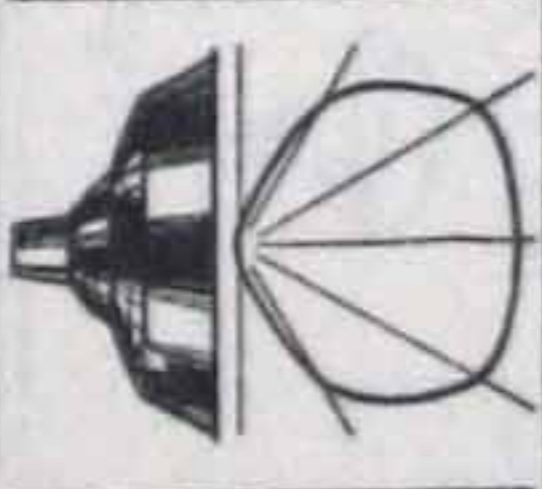
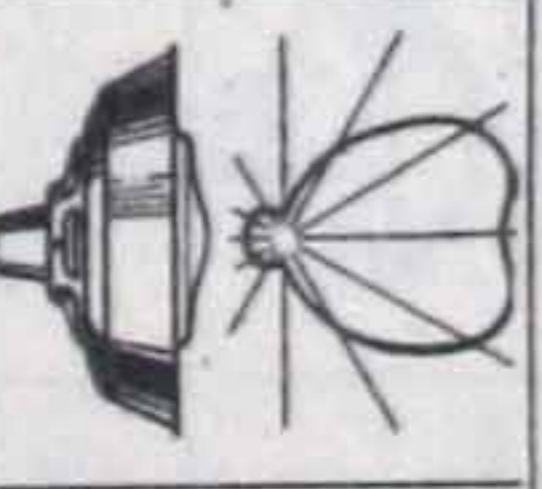
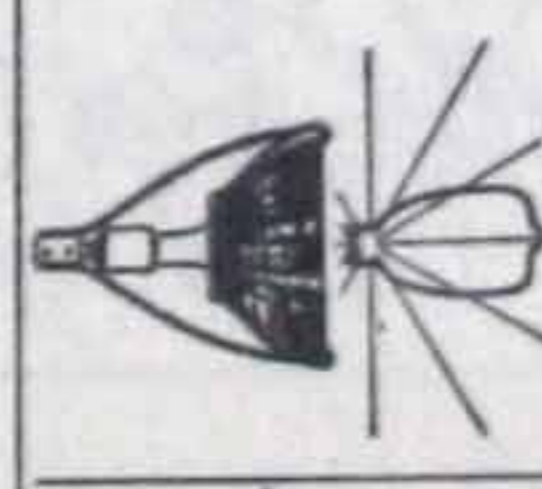
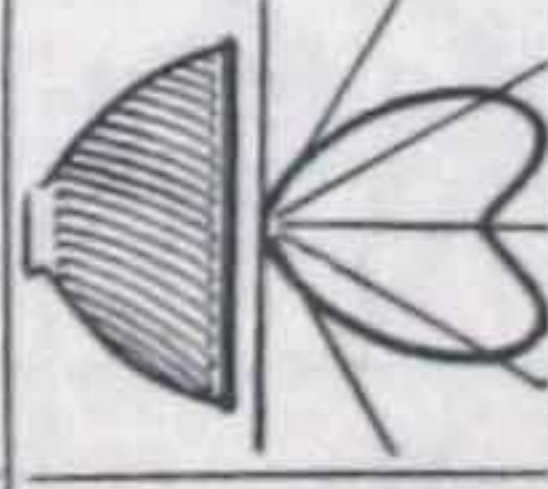
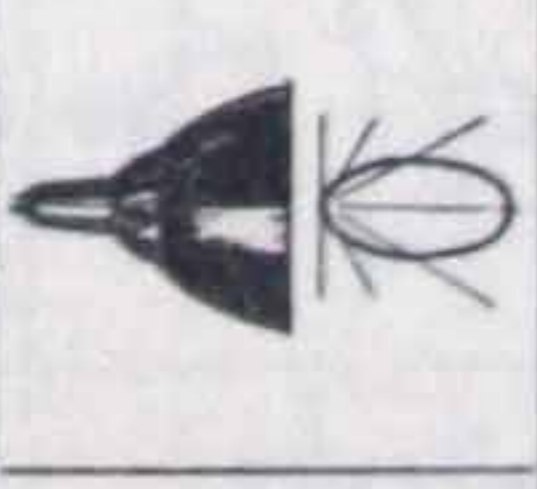
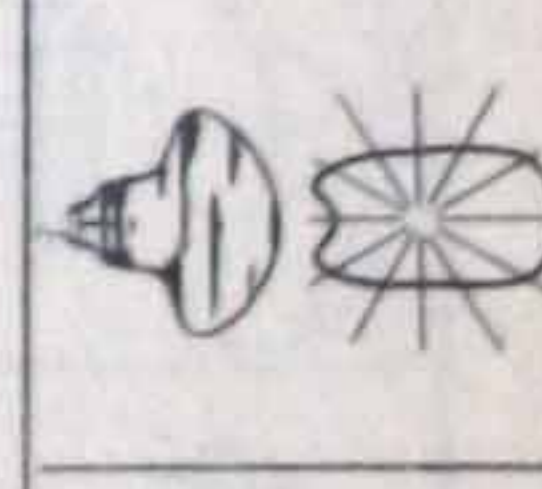
These values are given on
the opposite page

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TABLE 4-A A GUIDE TO THE SELECTION OF REFLECTING EQUIPMENT AND COEFFICIENTS OF UTILIZATION

| LIGHTING UNIT | EFFICIENCY BASED UPON | | APPEAR- ANCE OF LIGHTED ROOM | DIRECT GLARE | RE- FLECTED GLARE | SHADOWS | MAIN- TENANCE |
|--|---|----------------------------------|---------------------------------------|--------------------|-------------------------|---------|--------------------|
| | UPON | | | | | | |
| | Illumina- tion On Horizontal | Illumina- tion On Vertical | | | | | |
| Direct Lighting—General Industrial Reflectors | | | | | | | |
| 1 RLM Dome White Bowl Lamp 90° to 180°—0% 0° to 90°—66% |  | A Excellent | B Good | B+ | B | B+ | A— Very Good |
| 2 RLM Dome Clear Lamp 90° to 180°—0% 0° to 60°—76% |  | A+ | B+ | C | D | C+ | A+ |
| 3 Glastrad Diffuser Clear Lamp 90° to 180°—7% 0° to 90°—60% |  | A— Very Good | B Good | A— Very Good | B+ | A | B |
| High Mounting—Industrial Reflectors | | | | | | | |
| 4 Concentrated Prismatic Reflector Aluminum Cover Clear Lamp 90° to 180°—14% 0° to 90°—65% |  | A+ | B Good | C+ | D | C | A |
| 5 Mirrored Glass Reflector Clear Lamp 90° to 180°—0% 0° to 60°—70% |  | A+ | B Good | C+ | D | C | A |
| 6 Polished Aluminum Reflector Clear Lamp 90° to 180°—0% 0° to 90°—72% |  | A+ | B Good | C | D | C+ | A— Very Good |
| 7 White Glass Enclosing Globe 90° to 180°—35% 0° to 90°—45% |  | B+ | B+ | B | B+ | A— | B+ |

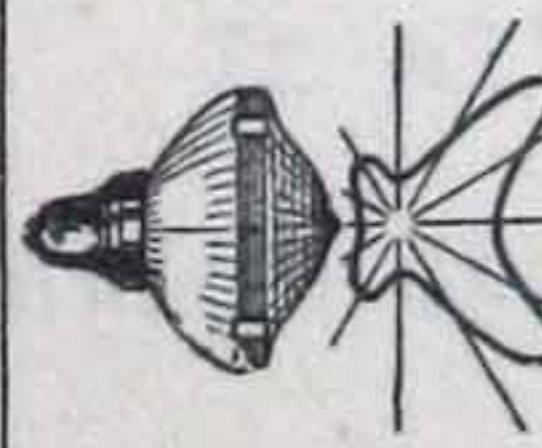
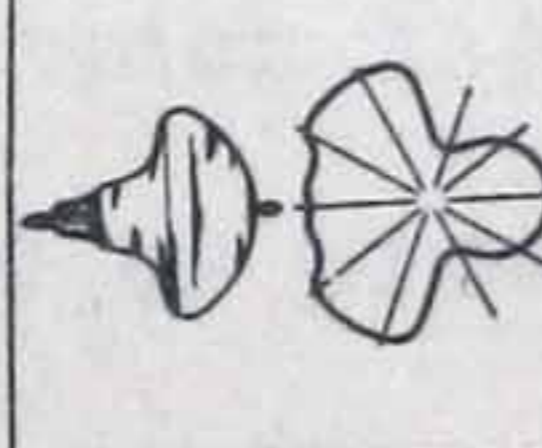
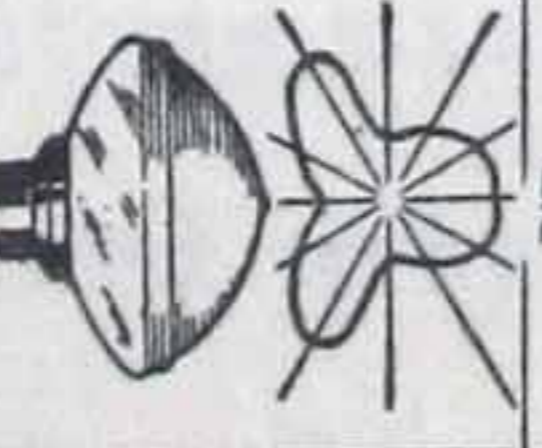
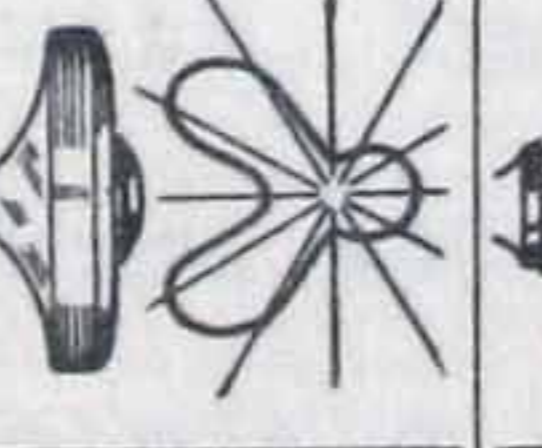
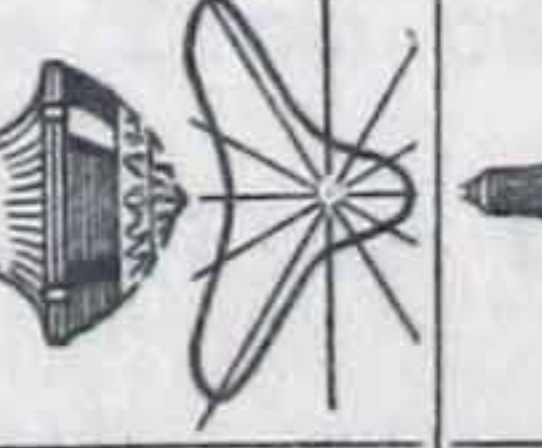
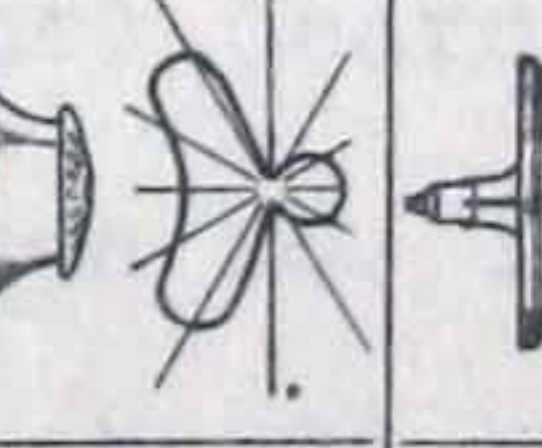

| COEFFICIENTS OF UTILIZATION | | | | | | | | | | | | | |
|--------------------------------|--------------------|---------|------------|--------------------|-------------------|--------------------|-------------------|--------------------|-------------------|--------------------|-------------------|--------------------|-------------------|
| DEPRECIATION FACTOR | | CEILING | | VERY LIGHT (30%) | | FAIRLY LIGHT (30%) | | VERY DARK (10%) | | FAIRLY DARK (30%) | | VERY DARK (10%) | |
| Clean Conditions | Average Conditions | Walls | Room Index | Fairly Light (30%) | Fairly Dark (30%) | Fairly Light (30%) | Fairly Dark (30%) | Fairly Light (30%) | Fairly Dark (30%) | Fairly Light (30%) | Fairly Dark (30%) | Fairly Light (30%) | Fairly Dark (30%) |
| Calculation Data—General Units | | | | | | | | | | | | | |
| .80 | .75 | .65 | 0.6 | .32 | .28 | .25 | .32 | .28 | .25 | .32 | .28 | .25 | .32 |
| | | | 0.8 | .40 | .36 | .34 | .42 | .38 | .34 | .42 | .38 | .34 | .42 |
| | | | 1.0 | .43 | .39 | .37 | .45 | .41 | .37 | .45 | .41 | .37 | .45 |
| | | | 1.2 | .46 | .43 | .41 | .48 | .45 | .43 | .48 | .45 | .43 | .48 |
| | | | 1.5 | .48 | .45 | .43 | .51 | .49 | .47 | .51 | .49 | .47 | .51 |
| | | | 2.0 | .52 | .50 | .48 | .55 | .53 | .51 | .55 | .53 | .51 | .55 |
| | | | 2.5 | .56 | .55 | .53 | .58 | .56 | .54 | .58 | .56 | .54 | .58 |
| .80 | .75 | .70 | 0.6 | .34 | .29 | .24 | .34 | .29 | .24 | .34 | .29 | .24 | .34 |
| | | | 0.8 | .42 | .38 | .34 | .42 | .37 | .33 | .42 | .37 | .33 | .42 |
| | | | 1.0 | .46 | .43 | .39 | .45 | .42 | .39 | .45 | .42 | .39 | .45 |
| | | | 1.2 | .50 | .47 | .43 | .49 | .46 | .43 | .49 | .46 | .43 | .49 |
| | | | 1.5 | .53 | .50 | .46 | .52 | .49 | .46 | .52 | .49 | .46 | .52 |
| | | | 2.0 | .58 | .55 | .51 | .57 | .54 | .51 | .57 | .54 | .51 | .57 |
| | | | 2.5 | .62 | .59 | .56 | .61 | .58 | .56 | .61 | .58 | .56 | .61 |
| .75 | .70 | .60 | 0.6 | .34 | .29 | .24 | .34 | .29 | .24 | .34 | .29 | .24 | .34 |
| | | | 0.8 | .42 | .38 | .34 | .42 | .37 | .33 | .42 | .37 | .33 | .42 |
| | | | 1.0 | .46 | .43 | .39 | .45 | .42 | .39 | .45 | .42 | .39 | .45 |
| | | | 1.2 | .50 | .47 | .43 | .49 | .46 | .43 | .49 | .46 | .43 | .49 |
| | | | 1.5 | .53 | .50 | .46 | .52 | .49 | .46 | .52 | .49 | .46 | .52 |
| | | | 2.0 | .58 | .55 | .51 | .57 | .54 | .51 | .57 | .54 | .51 | .57 |
| | | | 2.5 | .62 | .59 | .56 | .61 | .58 | .56 | .61 | .58 | .56 | .61 |
| .80 | .75 | .65 | 0.6 | .32 | .28 | .25 | .32 | .28 | .25 | .32 | .28 | .25 | .32 |
| | | | 0.8 | .36 | .32 | .29 | .35 | .31 | .28 | .35 | .31 | .28 | .35 |
| | | | 1.0 | .39 | .36 | .33 | .38 | .35 | .33 | .38 | .35 | .33 | .38 |
| | | | 1.2 | .42 | .39 | .36 | .41 | .38 | .36 | .41 | .38 | .36 | .41 |
| | | | 1.5 | .45 | .42 | .39 | .43 | .40 | .38 | .43 | .40 | .38 | .43 |
| | | | 2.0 | .49 | .46 | .43 | .48 | .45 | .43 | .48 | .45 | .43 | .48 |
| | | | 2.5 | .53 | .50 | .47 | .51 | .49 | .47 | .51 | .49 | .47 | .51 |
| .80 | .75 | .60 | 0.6 | .34 | .29 | .24 | .34 | .29 | .24 | .34 | .29 | .24 | .34 |
| | | | 0.8 | .42 | .38 | .34 | .42 | .37 | .33 | .42 | .37 | .33 | .42 |
| | | | 1.0 | .46 | .43 | .39 | .45 | .42 | .39 | .45 | .42 | .39 | .45 |
| | | | 1.2 | .50 | .47 | .43 | .49 | .46 | .43 | .49 | .46 | .43 | .49 |
| | | | 1.5 | .53 | .50 | .46 | .52 | .49 | .46 | .52 | .49 | .46 | .52 |
| | | | 2.0 | .58 | .55 | .51 | .57 | .54 | .51 | .57 | .54 | .51 | .57 |
| | | | 2.5 | .62 | .59 | .56 | .61 | .58 | .56 | .61 | .58 | .56 | .61 |
| .80 | .75 | .60 | 0.6 | .32 | .28 | .25 | .32 | .28 | .25 | .32 | .28 | .25 | .32 |
| | | | 0.8 | .36 | .32 | .29 | .35 | .31 | .28 | .35 | .31 | .28 | .35 |
| | | | 1.0 | .39 | .36 | .33 | .38 | .35 | .33 | .38 | .35 | .33 | .38 |
| | | | 1.2 | .42 | .39 | .36 | .41 | .38 | .36 | .41 | .38 | .36 | .41 |
| | | | 1.5 | .45 | .42 | .39 | .43 | .40 | .38 | .43 | .40 | .38 | .43 |
| | | | 2.0 | .49 | .46 | .43 | .48 | .45 | .43 | .48 | .45 | .43 | .48 |
| | | | 2.5 | .53 | .50 | .47 | .51 | .49 | .47 | .51 | .49 | .47 | .51 |
| .80 | .75 | .60 | 0.6 | .34 | .29 | .24 | .34 | .29 | .24 | .34 | .29 | .24 | .34 |
| | | | 0.8 | .42 | .38 | .34 | .42 | .37 | .33 | .42 | .37 | .33 | .42 |
| | | | 1.0 | .46 | .43 | .39 | .45 | .42 | .39 | .45 | .42 | .39 | .45 |
| | | | 1.2 | .50 | .47 | .43 | .49 | .46 | .43 | .49 | .46 | .43 | .49 |
| | | | 1.5 | .53 | .50 | .46 | .52 | .49 | .46 | .52 | .49 | .46 | .52 |
| | | | 2.0 | .58 | .55 | .51 | .57 | .54 | .51 | .57 | .54 | .51 | .57 |
| | | | 2.5 | .62 | .59 | .56 | .61 | .58 | .56 | .61 | .58 | .56 | .61 |
| .80 | .75 | .60 | 0.6 | .32 | .28 | .25 | .32 | .28 | .25 | .32 | .28 | .25 | .32 |
| | | | 0.8 | .36 | .32 | .29 | .35 | .31 | .28 | .35 | .31 | .28 | .35 |
| | | | 1.0 | .39 | .36 | .33 | .38 | .35 | .33 | .38 | .35 | .33 | .38 |
| | | | 1.2 | .42 | .39 | .36 | .41 | .38 | .36 | .41 | .38 | .36 | .41 |
| | | | 1.5 | .45 | .42 | .39 | .43 | .40 | .38 | .43 | .40 | .38 | .43 |
| | | | 2.0 | .49 | .46 | .43 | .48 | .45 | .43 | .48 | .45 | .43 | .48 |
| | | | 2.5 | .53 | .50 | .47 | .51 | .49 | .47 | .51 | .49 | .47 | .51 |
| .80 | .75 | .60 | 0.6 | .34 | .29 | .24 | .34 | .29 | .24 | .34 | .29 | .24 | .34 |
| | | | 0.8 | .42 | .38 | .34 | .42 | .37 | .33 | .42 | .37 | .33 | .42 |
| | | | 1.0 | .46 | .43 | .39 | .45 | .42 | .39 | .45 | .42 | .39 | .45 |
| | | | 1.2 | .50 | .47 | .43 | .49 | .46 | .43 | .49 | .46 | .43 | .49 |
| | | | 1.5 | .53 | .50 | .46 | .52 | .49 | .46 | .52 | .49 | .46 | .52 |
| | | | 2.0 | .58 | .55 | .51 | .57 | .54 | .51 | .57 | .54 | .51 | .57 |
| | | | 2.5 | .62 | .59 | .56 | .61 | .58 | .56 | .61 | .58 | .56 | .61 |
| .80 | .75 | .60 | 0.6 | .32 | .28 | .25 | .32 | .28 | .25 | .32 | .28 | .25 | .32 |
| | | | 0.8 | .36 | .32 | .29 | .35 | .31 | .28 | .35 | .31 | .28 | .35 |
| | | | 1.0 | .39 | .36 | .33 | .38 | .35 | .33 | .38 | .35 | .33 | .38 |
| | | | 1.2 | .42 | .39 | .36 | .41 | .38 | .36 | .41 | .38 | .36 | .41 |
| | | | 1.5 | .45 | .42 | .39 | .43 | .40 | .38 | .43 | .40 | .38 | .43 |
| | | | 2.0 | .49 | .46 | .43 | .48 | .45 | .43 | .48 | .45 | .43 | .48 |
| | | | 2.5 | .53 | .50 | .47 | .51 | .49 | .47 | .51 | .49 | .47 | .51 |
| .80 | .75 | .60 | 0.6 | .34 | .29 | .24 | .34 | .29 | .24 | .34 | .29 | .24 | .34 |
| | | | 0.8 | .42 | .38 | .34 | .42 | .37 | .33 | .42 | .37 | .33 | .42 |
| | | | 1.0 | .46 | .43 | .39 | .45 | .42 | .39 | .45 | .42 | .39 | .45 |
| | | | 1.2 | .50 | .47 | .43 | .49 | .46 | .43 | .49 | .46 | .43 | .49 |
| | | | 1.5 | .53 | .50 | .46 | .52 | .49 | .46 | .52 | .49 | .46 | .52 |
| | | | 2.0 | .58 | .55 | .51 | .57 | .54 | .51 | .57 | .54 | .51 | .57 |
| | | | 2.5 | .62 | .59 | .56 | .61 | .58 | .56 | .61 | .58 | .56 | .61 |
| .80 | .75 | .60 | 0.6 | .32 | .28 | .25 | .32 | .28 | .25 | .32 | .28 | .25 | .32 |
| | | | 0.8 | .36 | .32 | .29 | .35 | .31 | .28 | .35 | .31 | .28 | .35 |
| | | | 1.0 | .39 | .36 | .33 | .38 | .35 | .33 | .38 | .35 | .33 | .38 |
| | | | 1.2 | .42 | .39 | .36 | .41 | .38 | .36 | .41 | .38 | .36 | .41 |
| | | | 1.5 | .45 | .42 | .39 | .43 | .40 | .38 | .43 | .40 | .38 | .43 |
| | | | 2.0 | .49 | .46 | .43 | .48 | .45 | .43 | .48 | .45 | .43 | .48 |
| | | | 2.5 | .53 | .50 | .47 | .51 | .49 | .47 | .51 | .49 | .47 | .51 |
| .80 | .75 | .60 | 0.6 | .34 | .29 | .24 | .34 | .29 | .24 | .34 | .29 | .24 | .34 |
| | | | 0.8 | .42 | .38 | .34 | .42 | .37 | .33 | .42 | .37 | .33 | .42 |
| | | | 1.0 | .46 | .43 | .39 | .45 | .42 | .39 | .45 | .42 | .39 | |

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TABLE 4-B A GUIDE TO THE SELECTION OF REFLECTING EQUIPMENT AND COEFFICIENTS OF UTILIZATION

| LIGHTING UNIT | EFFICIENCY BASED UPON | | APPEAR- ANCE OF LIGHTED ROOM | DIRECT GLARE | RE- FLECTED GLARE | SHADOWS | MAIN- TENANCE |
|---|---|--------------------|---------------------------------------|-----------------|-------------------------|--------------------|--------------------|
| | Illumina- tion On | | | | | | |
| | Horizontal | Vertical | | | | | |
| Store and General Utility Enclosing Units | | | | | | | |
| 8 Prismatic Glass Enclosing Unit 90° to 180°—27% 0° to 90°—53% |  | A— Very Good | B+ | A | B | B— Very Fair | B Good |
| Semi-Indirect and Indirect Lighting Units | | | | | | | |
| 9 Enclosed Semi-Indirect Enamelled Bottom Etched Top 90° to 180°—50% 0° to 90°—27% |  | B— Very Fair | B— Very Fair | A | A— Very Good | B+ | B Good |
| 10 Enclosed Semi-Indirect Enamelled Bottom Etched Top 90° to 180°—48% 0° to 90°—32% |  | B Good | B— Very Fair | A | A— Very Good | B+ | B Good |
| 11 Enclosed Semi-Indirect Case-Glass Bottom Etched Top 90° to 180°—51% 0° to 90°—21% |  | C+ Very Fair | C+ Very Fair | A | A | A | B— Very Fair |
| 12 Enclosed Semi-Indirect Prismatic Glass Bottom Plate 90° to 180°—69% 0° to 90°—17% |  | B— Very Fair | C+ Very Fair | A | A | A | B Good |
| 13 Open Semi-Indirect Enamelled Reflector Dense Glass Bottom Plate 90° to 180°—54% 0° to 90°—18% |  | B— Very Fair | C | A | A— Very Good | B+ | C Fair |
| 14 Open Indirect 90° to 180°—80% 0° to 90°—0% |  | C+ Very Fair | C | B+ | A+ | A+ | C Fair |

| DEPRECIATION FACTOR | | CEILING | VERY LIGHT (70%) | | FAIRLY LIGHT (50%) | | FAIRLY DARK (30%) | | VERY DARK (10%) | | | | | | | | | |
|---|-------------------|------------|--------------------|-----------------|--------------------|-----------------|--------------------|-----------------|--------------------|-----------------|--|--|--|--|--|--|--|--|
| Clean Condition | Average Condition | | FAIRLY LIGHT (30%) | VERY DARK (10%) | FAIRLY LIGHT (30%) | VERY DARK (10%) | FAIRLY LIGHT (30%) | VERY DARK (10%) | FAIRLY LIGHT (30%) | VERY DARK (10%) | | | | | | | | |
| | | WALLS | | | | | | | | | | | | | | | | |
| | | ROOM INDEX | | | | | | | | | | | | | | | | |
| COEFFICIENTS OF UTILIZATION | | | | | | | | | | | | | | | | | | |
| Calculation Data—Enclosing Units—Cont'd. | | | | | | | | | | | | | | | | | | |
| .80 | .70 | .60 | .28 | .22 | .18 | .26 | .21 | .17 | .19 | .16 | | | | | | | | |
| | | | .35 | .29 | .25 | .33 | .28 | .24 | .26 | .23 | | | | | | | | |
| | | | .38 | .33 | .29 | .36 | .32 | .28 | .30 | .27 | | | | | | | | |
| | | | .43 | .37 | .33 | .40 | .35 | .31 | .33 | .30 | | | | | | | | |
| | | | .46 | .41 | .36 | .43 | .38 | .34 | .35 | .33 | | | | | | | | |
| | | | .51 | .46 | .42 | .47 | .43 | .40 | .40 | .38 | | | | | | | | |
| | | | .55 | .51 | .46 | .51 | .47 | .44 | .44 | .42 | | | | | | | | |
| | | | .58 | .54 | .50 | .54 | .50 | .47 | .46 | .44 | | | | | | | | |
| | | | .62 | .58 | .55 | .57 | .54 | .51 | .50 | .48 | | | | | | | | |
| | | | .65 | .61 | .57 | .60 | .56 | .53 | .52 | .50 | | | | | | | | |
| Calculation Data—Semi-Indirect and Indirect Units | | | | | | | | | | | | | | | | | | |
| .75 | .70 | ... | .17 | .13 | .10 | .14 | .11 | .09 | .08 | .07 | | | | | | | | |
| | | | .21 | .17 | .14 | .18 | .14 | .12 | .12 | .10 | | | | | | | | |
| | | | .24 | .20 | .17 | .21 | .17 | .15 | .14 | .12 | | | | | | | | |
| | | | .28 | .23 | .20 | .23 | .19 | .17 | .16 | .14 | | | | | | | | |
| | | | .31 | .26 | .23 | .26 | .22 | .19 | .18 | .16 | | | | | | | | |
| | | | .35 | .30 | .27 | .29 | .25 | .22 | .20 | .18 | | | | | | | | |
| | | | .38 | .34 | .30 | .32 | .28 | .25 | .23 | .21 | | | | | | | | |
| | | | .41 | .37 | .33 | .34 | .30 | .27 | .25 | .22 | | | | | | | | |
| | | | .45 | .41 | .37 | .37 | .34 | .31 | .29 | .25 | | | | | | | | |
| | | | .47 | .43 | .40 | .41 | .37 | .35 | .31 | .27 | | | | | | | | |
| .75 | .70 | ... | .19 | .14 | .11 | .16 | .12 | .10 | .10 | .08 | | | | | | | | |
| | | | .24 | .19 | .16 | .21 | .16 | .14 | .14 | .12 | | | | | | | | |
| | | | .27 | .22 | .19 | .23 | .19 | .17 | .16 | .14 | | | | | | | | |
| | | | .30 | .25 | .22 | .26 | .22 | .19 | .18 | .16 | | | | | | | | |
| | | | .34 | .29 | .25 | .29 | .25 | .22 | .20 | .18 | | | | | | | | |
| | | | .38 | .33 | .29 | .32 | .28 | .25 | .23 | .21 | | | | | | | | |
| | | | .41 | .37 | .33 | .35 | .32 | .28 | .26 | .24 | | | | | | | | |
| | | | .44 | .40 | .36 | .38 | .34 | .31 | .28 | .26 | | | | | | | | |
| | | | .49 | .44 | .40 | .41 | .37 | .35 | .31 | .29 | | | | | | | | |
| | | | .51 | .47 | .43 | .43 | .39 | .37 | .33 | .31 | | | | | | | | |
| .75 | .65 | ... | .16 | .12 | .10 | .13 | .10 | .08 | .08 | .07 | | | | | | | | |
| | | | .20 | .16 | .14 | .17 | .14 | .11 | .11 | .09 | | | | | | | | |
| | | | .23 | .19 | .17 | .19 | .16 | .14 | .13 | .11 | | | | | | | | |
| | | | .26 | .22 | .19 | .22 | .18 | .16 | .14 | .13 | | | | | | | | |
| | | | .29 | .25 | .21 | .24 | .20 | .19 | .16 | .14 | | | | | | | | |
| | | | .32 | .28 | .25 | .27 | .23 | .21 | .18 | .17 | | | | | | | | |
| | | | .35 | .31 | .28 | .29 | .26 | .24 | .20 | .19 | | | | | | | | |
| | | | .38 | .34 | .31 | .31 | .28 | .26 | .22 | .21 | | | | | | | | |
| | | | .41 | .36 | .33 | .34 | .31 | .29 | .24 | .23 | | | | | | | | |
| | | | .43 | .39 | .37 | .36 | .33 | .31 | .26 | .24 | | | | | | | | |
| .75 | .70 | ... | .18 | .14 | .11 | .14 | .11 | .09 | .07 | .06 | | | | | | | | |
| | | | .22 | .18 | .15 | .18 | .14 | .12 | .10 | .09 | | | | | | | | |
| | | | .25 | .21 | .18 | .20 | .17 | .14 | .12 | .10 | | | | | | | | |
| | | | .29 | .24 | .21 | .23 | .19 | .17 | .14 | .12 | | | | | | | | |
| | | | .33 | .28 | .24 | .26 | .22 | .19 | .16 | .14 | | | | | | | | |
| | | | .36 | .32 | .28 | .29 | .25 | .22 | .18 | .16 | | | | | | | | |
| | | | .40 | .35 | .32 | .31 | .28 | .25 | .20 | .18 | | | | | | | | |
| | | | .43 | .38 | .35 | .33 | .30 | .27 | .22 | .20 | | | | | | | | |
| | | | .47 | .43 | .39 | .37 | .34 | .31 | .24 | .23 | | | | | | | | |
| | | | .49 | .45 | .42 | .39 | .36 | .33 | .26 | .24 | | | | | | | | |
| .75 | .70 | ... | .15 | .11 | .09 | .12 | .09 | .07 | .05 | .04 | | | | | | | | |
| | | | .18 | .14 | .11 | .15 | .12 | .10 | .08 | .06 | | | | | | | | |
| | | | .22 | .18 | .15 | .18 | .14 | .12 | .10 | .08 | | | | | | | | |
| | | | .25 | .21 | .18 | .20 | .17 | .14 | .12 | .10 | | | | | | | | |
| | | | .29 | .24 | .21 | .23 | .19 | .17 | .15 | .13 | | | | | | | | |
| | | | .33 | .28 | .24 | .26 | .22 | .19 | .16 | .14 | | | | | | | | |
| | | | .36 | .32 | .28 | .29 | .25 | .22 | .19 | .16 | | | | | | | | |
| | | | .40 | .35 | .32 | .31 | .28 | .25 | .20 | .18 | | | | | | | | |
| | | | .43 | .38 | .35 | .33 | .30 | .27 | .22 | .20 | | | | | | | | |
| | | | .47 | .43 | .39 | .37 | .34 | .31 | .24 | .23 | | | | | | | | |
| | | | .49 | .45 | .42 | .39 | .36 | .33 | .26 | .24 | | | | | | | | |
| .75 | .70 | ... | .12 | .09 | .07 | .11 | .08 | .06 | .05 | .04 | | | | | | | | |
| | | | .15 | .11 | .09 | .12 | .09 | .07 | .05 | .04 | | | | | | | | |
| | | | .18 | .13 | .11 | .15 | .12 | .10 | .08 | .06 | | | | | | | | |
| | | | .22 | .17 | .14 | .18 | .14 | .12 | .10 | .08 | | | | | | | | |
| | | | .25 | .20 | .17 | .21 | .17 | .15 | .13 | .11 | | | | | | | | |
| | | | .28 | .23 | .20 | .24 | .20 | .18 | .15 | .13 | | | | | | | | |
| | | | .31 | .26 | .23 | .27 | .23 | .21 | .18 | .15 | | | | | | | | |
| | | | .34 | .29 | .26 | .30 | .26 | .24 | .21 | .18 | | | | | | | | |
| | | | .37 | .32 | .29 | .32 | .28 | .26 | .23 | .21 | | | | | | | | |
| | | | .40 | .35 | .32 | .34 | .30 | .28 | .25 | .22 | | | | | | | | |
| | | | .43 | .38 | .35 | .37 | .33 | .31 | .28 | .25 | | | | | | | | |
| | | | .44 | .41 | .38 | .41 | .37 | .34 | .31 | .28 | | | | | | | | |

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TABLE 5
LUMEN OUTPUT OF MULTIPLE MAZDA LAMPS
 (Subject to change without notice)

| 110-115-120 Volt General Lighting Service Clear Bulb Lamps | | 110-115-120 Volt General Lighting Service Daylight Bulb Lamps | | 220-230-240-250 Volt Service Clear Bulb Lamps | |
|--|-----------------|---|------------------|---|-----------------|
| Size of Lamp in Watts | Lumen Output | Size of Lamp in Watts | Lumen* Output | Size of Lamp in Watts | Lumen Output |
| **100 | 1360 | **100 | 884 | **100 | 1030 |
| 150 | 2295 | 150 | 1492 | ... | |
| 200 | 3340 | 200 | 2170 | 200 | 2660 |
| 300 | 5370 | 300 | 3490 | 300 | 4290 |
| 500 | 9650 | 500 | 6180 | 500 | 7750 |
| 750 | 14550 | ... | | 750 | 12600 |
| 1000 | 20200 | ... | | 1000 | 18200 |

*Approximate values

**Inside frosted bulb

AMPLE WIRING CAPACITY

In municipalities where 15 ampere (115 volts) fusing of branch circuits is permitted, the loading per circuit of the initial installation in a commercial or industrial interior should not exceed 1000 watts. A branch circuit should supply the lighting load for a rentable area or work space not greater than 400 square feet or equivalent bay approximately 20 by 20 feet. A branch circuit should not supply the lighting load for more than 800 square feet of hall space, passageway, non-rentable or non-productive area.

In all branch lighting circuits, runs from panel board to the first outlet should be provided with wire not smaller than No. 12 B & S gauge size. No smaller than No. 10 B & S gauge wire should be used for runs of 50 to 100 feet from panel board to first outlet, and wire no smaller than No. 12 B & S between outlets.

Whenever possible, runs exceeding 100 feet from the panel board to the first outlet should be avoided. Provide additional panel boards or relocate present ones. However, where such runs cannot be avoided, the initial lamp load should be limited to 600 watts per circuit, and wire not smaller than No. 10 B & S gauge should be used between the panel board and first outlet.

Wall or baseboard outlets should not be placed on any circuit supplying overhead lighting outlets. For convenience, wall or baseboard outlets should be of the duplex type. Not more than 8 duplex outlets should be placed on one circuit. Use not smaller than No. 12 B & S gauge wire where the run from panel board to first convenience outlet is less than 100 feet, and not smaller than No. 10 B & S gauge wire where the run exceeds 100 feet.

It is recommended that conduits for enclosing feeder wires should be of sufficient size to allow replacing the original feeder (if future expansion demands this alteration) with a feeder at least two standard B & S gauge sizes greater in capacity.

In localities where 15 ampere fusing at 115 volts is permitted, the feeders should be of such a size that the voltage drop from the service entrance to the panel board will not exceed $1\frac{1}{2}\%$ with a load of 10 amperes at 115 volts on every branch circuit provided for, including spares. Where a local electrical ordinance limits the permissible load per circuit to less than 10 amperes at 115 volts, the initial loading per circuit should be proportionately reduced.

Panel boards for controlling lighting circuits should contain a minimum of one spare circuit position for at least every five active circuits. Install at least one panel board on each floor of the building. Locate panel boards so that branch circuit runs to first outlet will not exceed 100 feet.

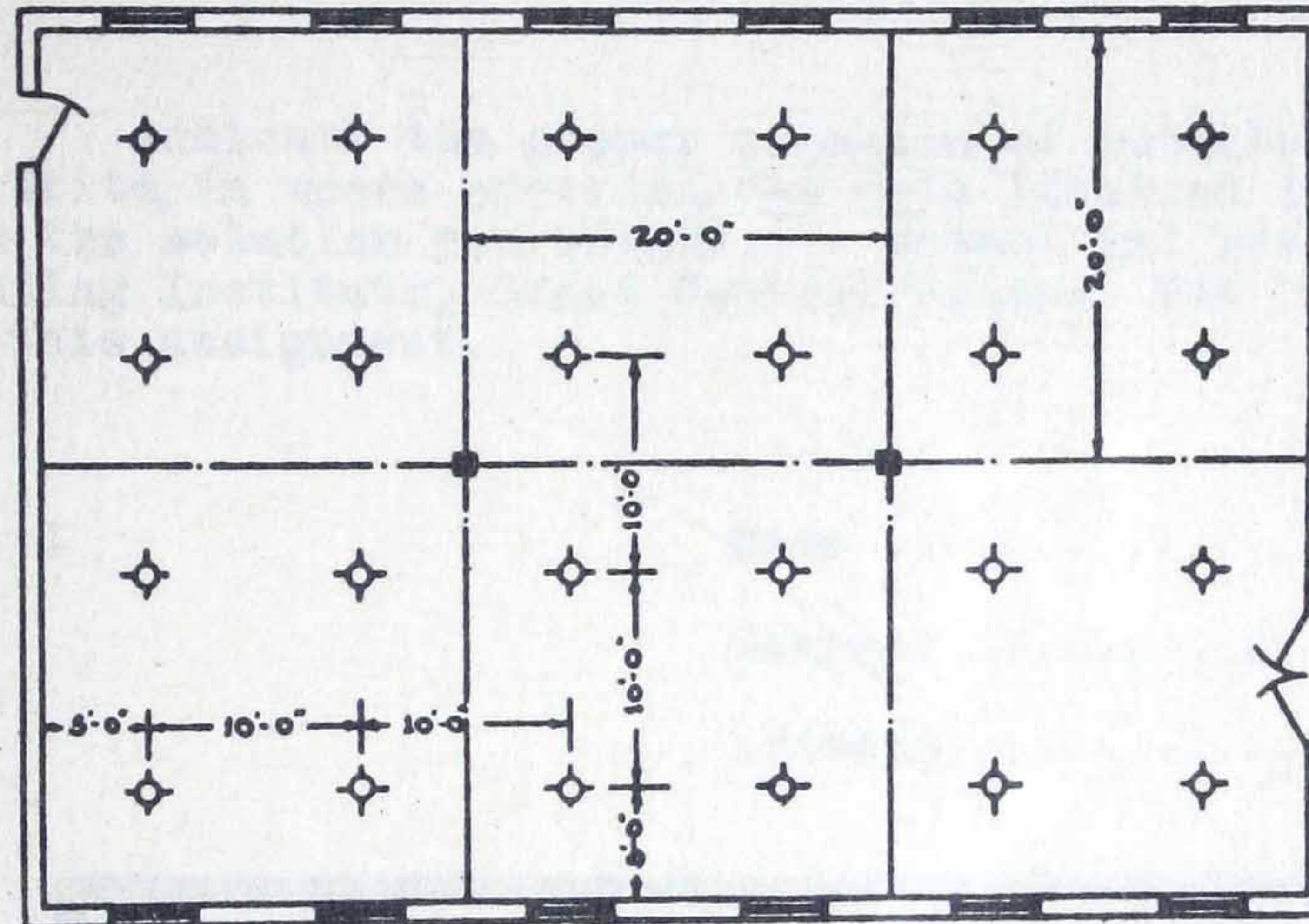
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EXAMPLETHE DESIGN OF AN INDUSTRIAL LIGHTING INSTALLATIONData

Machine shop in which medium grade work is done. Dirty white ceiling, 12 feet high, fairly clean buff walls, average maintenance. Floor plan indicates location of windows, doors and columns.

ComputationReference
Table

| | | |
|--|---|-----|
| 1. Foot-candles required | 12 | 1 |
| 2. Type of unit | RLM Dome No. 1 | 4-A |
| 3. Mounting Height | 10' | 2-B |
| 4. Spacing | 10' x 10' | 2-A |
| 5. Area per Outlet | $\frac{40 \times 60}{24} = 100$ sq. ft. | |
| 6. Room Index (Room 40' wide x 60' long) | 3.0 | 3-A |
| 7. Coef. of Utilization | 0.56 | 4-A |
| 8. Depreciation Factor | 0.75 | 4-A |
| 9. Formula | | |

$$\text{Lumens per Outlet} = \frac{\text{Area per Outlet} \times \text{Foot-Candles required}}{\text{Depreciation Factor} \times \text{Coef. of Utilization}}$$

$$= \frac{100 \times 12}{.75 \times .56} = 2857 \text{ (Lumens per Outlet)}$$

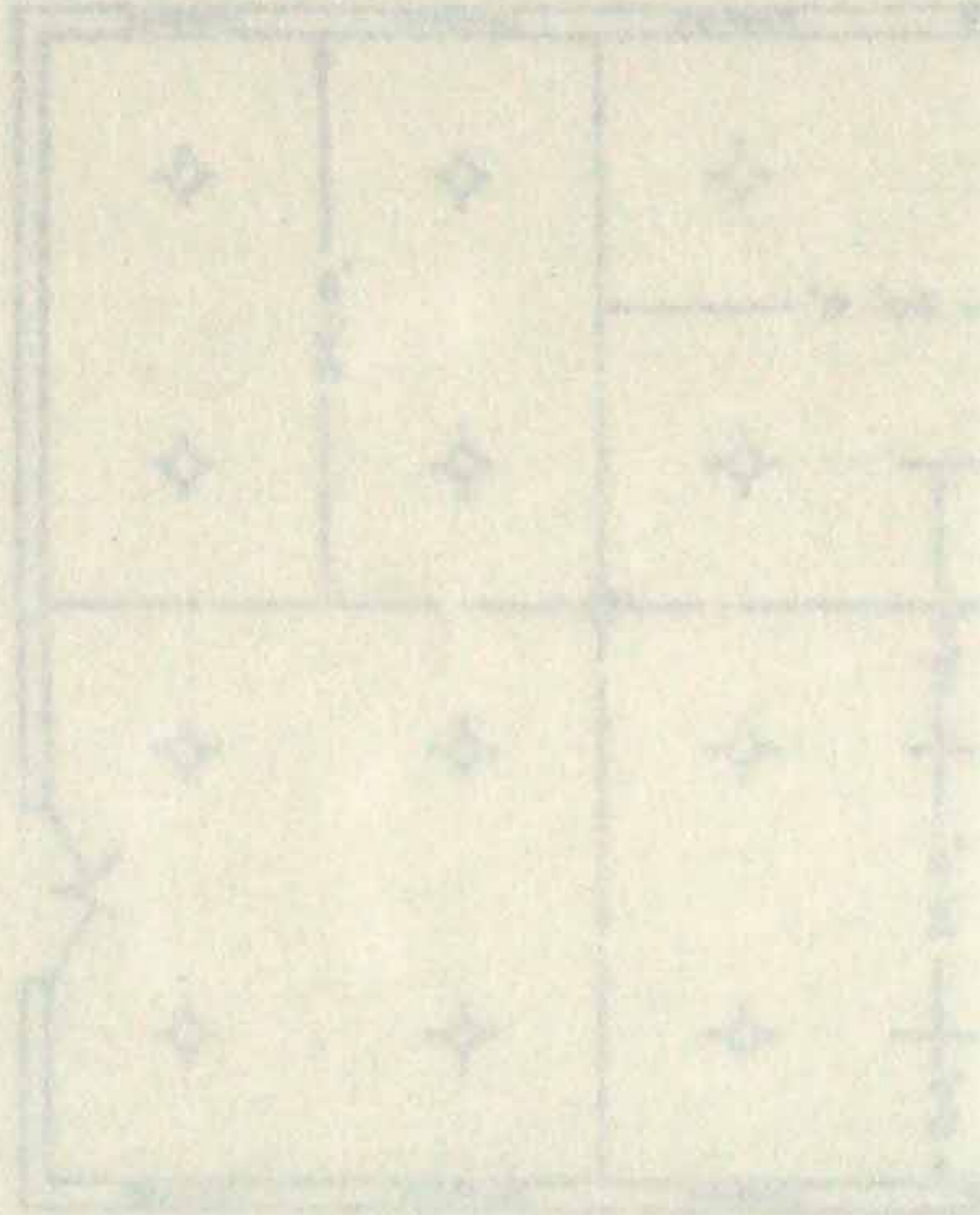
From Table 5, the lumen output nearest to 2857 is 3340 (assuming the service is 110-115-120 volts); one 200 watt lamp should be used at each outlet.

$$\text{Actual Illumination Provided} = \frac{3340}{2857} \times 12 = 13.9 \text{ F.C.}$$

EXAMPLE

INDUSTRIAL LIGHTING INSTALLATION

When ceiling grade work is done, keep clear built walls, average maintenance, windows, doors and columns.



Reference
Table

| | |
|-----|-----------------------|
| 1 | 12 |
| 4-4 | 12 |
| 2-2 | 10 |
| 2-1 | 10 |
| | 10 x 10 |
| | 40 x 60 = 100 sq. ft. |
| | 34 |
| 3-2 | 10 |
| 4-2 | 10 |
| 4-1 | 10 |

2 per outlet x foot-candle required
outlet factor x cost of utilization

12 = 2257 (lumens per outlet)
34

lumens output nearest to 2257 is 2340
230 volts; one 200 watt lamp should

2340 x 12 = 28080
2257

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LIGHTING DESIGN PROBLEMData

A high class shoe shop, with seats arranged as shown on the accompanying plan. Light colored boxes fill the shelves which completely cover the walls. The ceiling, which is 14 feet high, is finished in a very light cream.

Problem

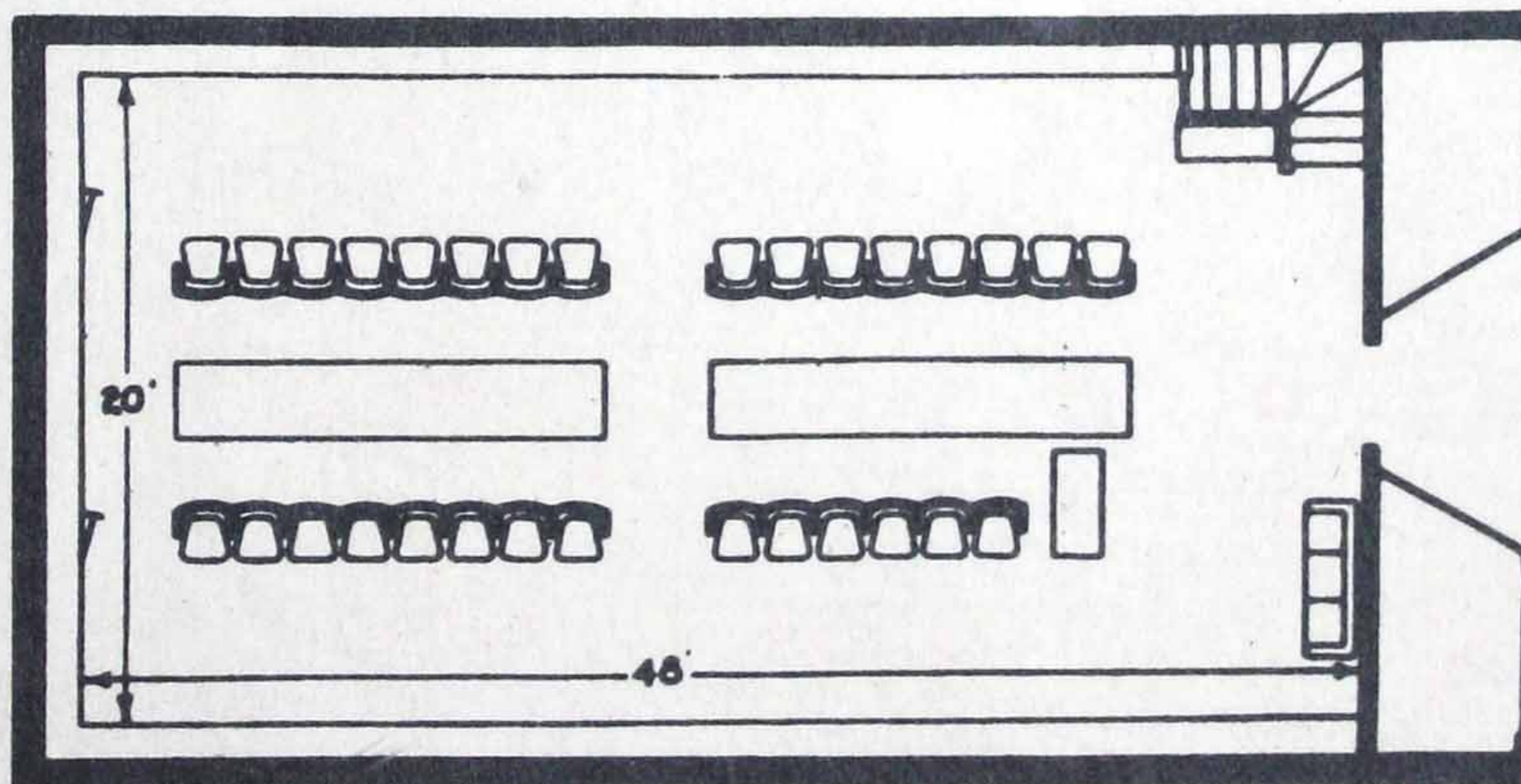
Indicate the proper location of outlets on the plan shown below. Write, in space provided, the data involved in your calculations and record the solution you obtain. Detach and return to the Westinghouse Lighting Institute, Grand Central Palace, New York, N.Y., as your answer to this assignment.

Assignment 4

Name

Company

Address

Computation

Foot-candles selected Area per outlet

Type of unit Room Index

Mounting Height Coef. of Utilization

Spacing Depreciation Factor

Solution

Size of lamp watts

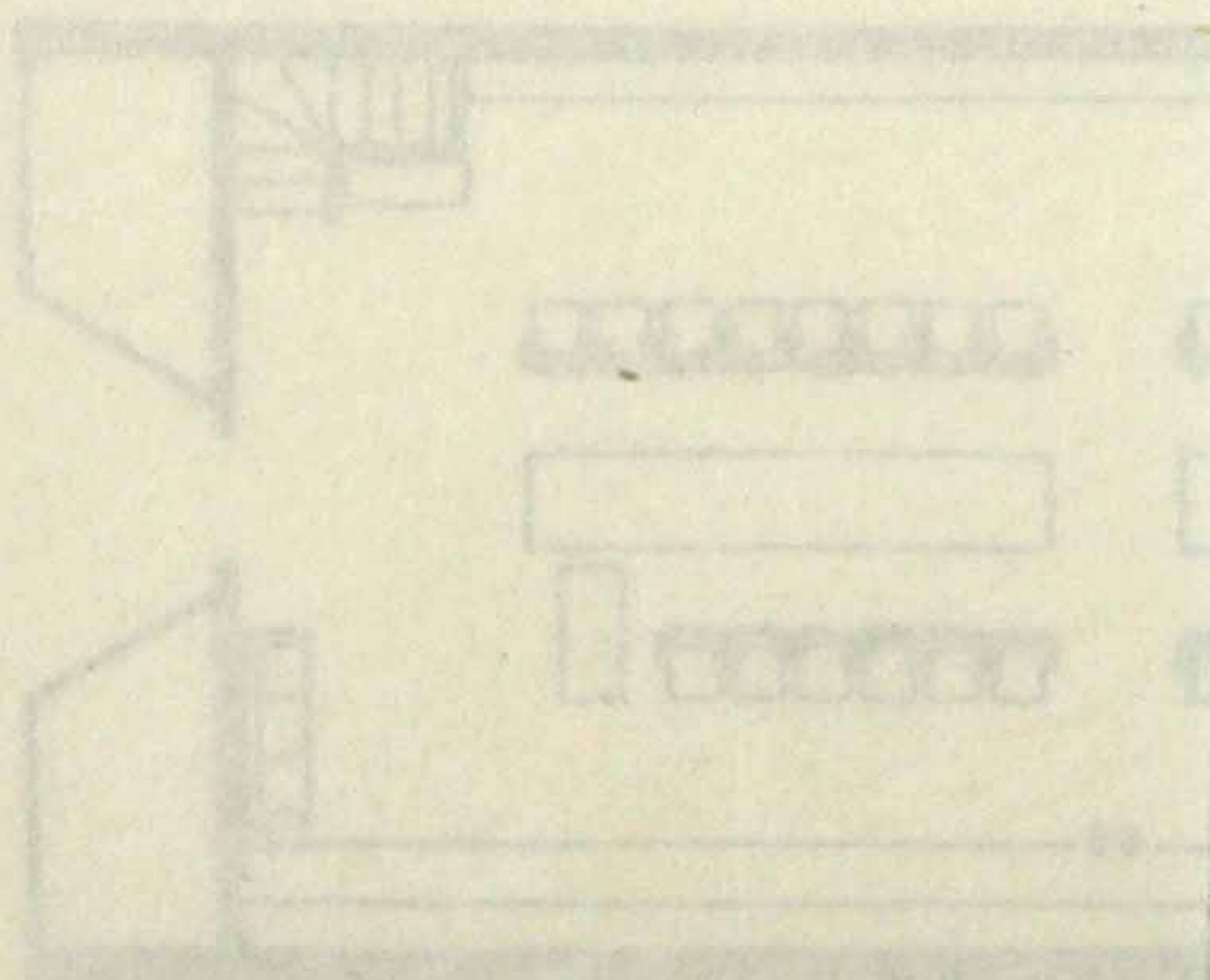
Actual illumination provided foot-candles.

THE DESIGN PROBLEM

ce shop with seats arranged as shown on the
shown below fill the shelves with cor-
ce ceiling which is 14 feet high in finished

per location of outlets on the plan shown
that the data involved in your calculations
again. Contact and return to the Receiving
and Control Bureau, New York, N.Y., as your

Name
Company
Address



Area per office
Room Index
Cost of Utilization
Depreciation Factor

Notes

Cost-calculation

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